

**Department of Energy/National Science Foundation
Mini-Review Report on the
U.S. LHC Accelerator Project**

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PLACE Fermi National Accelerator Laboratory

COMMITTEE

Lowell Ely, Chairperson, DOE/SC
Timothy Toohig, U.S. LHC Program Manager, DOE/SC
Bruce Strauss, U.S. LHC Accelerator Construction Program Manager, DOE/SC
Jim Yeck, U.S. LHC DOE/NSF Project Manager, Fermi Area Office
Pepin Carolan, Fermi Area Office
Jean Delaysen, Thomas Jefferson National Accelerator Facility
Phillip Sanger, Cleveland State University
Hans-Jorge Schneider-Muntau, National High Magnetic Field Laboratory

PROJECT STATUS

Total Project Cost (TPC):	\$110 million
Appropriations through FY01 :	\$72.37 million
Percent Complete:	Planned: 59 percent Actual: 64 percent
Project Completion Date:	Baseline: 09/05 Forecast: 09/05
CD-4 Date:	Baseline: 4 th Q FY05 Forecast: 4 th Q FY05

SUMMARY

The project baseline scope is supported by excellent technical progress including successful cryogenic tests of the first full size high-gradient quadrupole magnet at Fermilab, and completion of several Engineering Design Reviews.

Schedule performance remains slightly behind plan but on track for meeting the CERN need dates.

Cost variances, increased estimate to complete (ETC), and residual cost risk are continuing concerns and the Project Manager is taking strong action to keep costs in line.

PROJECT COST AND SCHEDULE STATUS

Overall the project is approximately three months behind the U.S. baseline schedule but ahead of the dates required by CERN for installation of the U.S. supplied equipment. This negative schedule variance has varied only slightly during the past year. There are no major schedule issues and there is high confidence that the project completion milestone of September 2005 will be met since delivery of equipment is scheduled to be completed in 2004.

Schedule issues arising from delays in CERN deliveries of components required for completing U.S. deliverables are a continuing concern but are being adequately addressed. There is significant progress on functional and interface specifications making the project less dependent on design related information from CERN.

The official CERN schedule for commissioning the LHC machine was recently revised. An octant test is scheduled for April-September 2004; first collisions in April 2006; and the first physics run beginning in August 2006.

The current total project cost of \$110 million is identical to the original baseline. The project has completed a new estimate at completion (EAC) by performing a bottoms-up cost estimate for the vast majority of the project. The new EAC presented at the review was \$103,166 K with \$6,834 K remaining as contingency. Contingency is approximately 17 percent of the \$40,468 K "cost-to-go." The project manager and the Committee agree that contingency at approximately 20 percent of the cost-to-go is needed.

Recommendations

1. Continue efforts to increase contingency in order to re-establish total project contingency at approximately 20 percent of the cost estimate to complete.
2. Continue to evaluate the detailed project scope to reduce costs without jeopardizing commitments to CERN.

TECHNICAL PROGRESS AND ISSUES

Fermi National Accelerator Laboratory (Fermilab)

Technical Accomplishments

The first prototype Q2P1 was successful. Great accomplishment! During this production, total touch labor for the cold mass and cryostat assembly was lower than expected.

Schedule

The Fermilab production schedule for complete magnets depends on KEK and LHC deliveries in key areas. Over the past six months, excellent progress has been made. With improved cryogenic capability, the KEK program is now consistent with U.S. LHC requirements. Recent CERN action has also resolved corrector coil delivery delays. The availability of beam tubes is now on the critical path and will require vigilance.

CERN/U.S. LHC Schedule Mismatch

It is now clear that the CERN LHC has been extended beyond the U.S. LHC project schedule. Nevertheless, in maintaining the present U.S. LHC schedule is vital to the completion within its budget of the U.S. project. In this light, unresolved interface requirements and acceptance criteria are a concern. The presence of two Fermilab engineers at CERN is an excellent mitigation measure and is fully supported by the Committee. Nevertheless, clear and

timely agreement on interface and acceptance criteria must be reached between CERN and the U.S. KEK has recently resolved acceptance criteria with LHC thereby providing a good model and basis for progress.

Cost Review

The evolution of the latest EAC reflects appropriate attention to this issue. In August 2000, a detailed bottoms-up estimate was completed resulting in a significant reduction of the Fermilab EAC, while consideration of actual labor rates against project defined escalation rates during the first quarter of FY 2001 resulted in an increased EAC. It should be expected that further adjustments will be required as the project proceeds. Over the past six months significant cost growth has appeared in the test stand setup. A few issues remain with the test stand but the cost of test stand set-up appears to be under control.

Fermilab is now moving into the production phase with solid cost estimates based on experience from prototype fabrication and a clear focus on the production phase. The actual costs of the prototypes have been incorporated into the EAC. The Committee applauds the cost control technique of closing tasks as quickly as possible. The EAC includes provision for yield losses with 12 percent parts and materials reserve and labor for coil fabrication. This reserve is doubled if the second prototype is converted into the first production magnet.

Contingency Review

The Committee would prefer that the contingency reserve not fall below 20 percent of the remaining costs. Nevertheless the 19 percent should be sufficient to absorb a potential five to seven percent labor rate adjustment if needed, and at least one rebuild of a magnet.

Recommendations

1. Define the acceptance criteria for the quadrupole magnets and secure CERN concurrence prior to the Production Readiness Review scheduled for summer 2001.
2. Resolve the remaining interface issues to confirm the quadrupole production schedule.
3. Maintain management vigilance in implementing the ramp-down of EDIA and technician resources to avoid potential cost overruns.
4. Strongly consider making Q2P2 (the second prototype) the first production magnet.

Brookhaven National Laboratory (BNL)

BNL is now into magnet production, which should reduce the uncertainty in cost projections. The timely availability of parts from CERN is still an issue. Recently there has been good progress in addressing interface specifications and resolving design issues.

As a result of continuing cost growth BNL has submitted two Baseline Change Requests (BCR) to the Project Manager for approval: BCR25 covers magnet production, and BCR26 addresses cable testing. Only BCR26 has been approved.

BCR26 results from the difficulty that CERN is experiencing with European production and deliveries of superconducting cable. Consequently, the BNL Cable Test Facility has been operating at well below full capacity. BNL and the U.S. LHC project have negotiated with CERN a revised level of effort agreement for the remainder of this project. The agreement covers a maximum annual rate of 800 equivalent 4.2 K tests through the second quarter of FY 2005. This assumes the ability of CERN to supply the requisite samples.

BCR25 covers magnet production and results from requests by the U.S. LHC project for a current ETC and a new bottoms-up cost estimate. BNL stated the major cost drivers include: wage inflation much higher than the DOE guidelines used in the original estimate, higher materials costs, and higher tooling costs. Overhead and space charges at BNL may present additional cost risk that needs to be understood and controlled. The interfacing with CERN and design maturation led to additional cost increases. BNL contends that man-hours are consistent with their original estimates. Cost reduction would include elimination of interconnect parts and termination of accelerator physics activities for example.

BNL estimates that the contingency required on the remainder of the project is approximately 13 percent. The Committee is uncomfortable with this level of contingency because of the potential for additional cost exposure.

In the last six months the BNL Associate Laboratory Director for High Energy and Nuclear Physics and the Magnet Division Head have become actively involved in the day-to-day management of the BNL effort. These managers have reviewed the new cost-to-complete and pledged to deliver on the new cost baseline. The Committee believes that the continued direct involvement in the execution of the BNL effort by the Magnet Division Head is vital.

Recommendations

1. Senior BNL management must stay fully engaged to ensure that the project is completed on time and budget.
2. Detailed project performance analysis is required to avoid cost overruns. Additional BNL staff support should be provided to perform this function.

Lawrence Berkeley National Laboratory (LBNL)

Absorbers

Good progress has been made on the absorbers portion of the project. The task is 48 percent complete according to the budget, and the design effort is 95 percent complete as measured by the number of drawings. This project is now entering the fabrication phase. Fabrication of the absorbers is scheduled to start in July 2001 and end in February 2002.

A review of the ETC has identified an increase of \$444 K from \$1,744 K to \$2,188 K between July 2000 and May 2001. The causes for the increase include:

- ~~/~~ Increase of fabrication cost (\$379 K) with about half due to labor
- ~~/~~ A change in the material and in the fabrication method for the copper absorbers
- ~~/~~ Allowance for rework
- ~~/~~ Increase in material handling labor
- ~~/~~ Space charges for Building 60

Some of these costs are offset by procurement costs that were lower than estimated, \$8.1 K vs. \$1.3 K.

DFBX (Distribution Feedboxes)

Substantial progress has been made on the feedboxes and the design is nearing completion. The requirements and interface definition are now understood.

A thorough assessment of the ETC was performed by reviewing all WBS items. The WBS was restructured to better support estimating and tracking production. The ETC review revealed some significant changes. A net change of the ETC of \$955 K from \$3,323 K to \$4,278 K was identified; this in spite of a positive variance of \$423 K due to a favorable cost on the high current test leads for the cryoboxes. The bulk of the change was due to a significant underestimate of the labor needed for design fabrication, assembly, and test oversight.

Fabrication, assembly, and testing will take place in parallel. Delivery of the first articles produced by vendors to LBNL is scheduled for first quarter FY 2003.

The schedule, as presented, has a four-month float in the delivery of the first item to CERN.

Estimated contingency for the project has been increased to 29 percent. This is based on using 40 percent for “physicists estimates” and 30 percent for “engineering estimates.”

Recommendations

1. Encourage CERN participation in the acceptance test of the first absorbers and feedboxes at LBNL.
2. Assign a full-time manager to the feedboxes portion of the project.

MANAGEMENT

The project management team is experienced and capable. The project systems for managing baseline, reporting, technical reviews, and coordination appear to be adequate for this stage of the project. Additional attention to technical and cost baseline control will be needed as the project moves forward.

The project office has done a good job of keeping a valid baseline.

There is excellent communication with CERN. The participation in the review by CERN managers was extremely helpful.

Cost variances and cost growth remain a significant concern. The slope of the increase in the ETC is particularly troublesome. In particular, the cost increases at BNL and LBNL remain a major source of concern.

At this review, the BNL Magnet Division head committed his personal involvement in the project to control and manage scope, costs, and schedule. The Committee expects that this commitment will be fully met.

Continued tight control of the detailed baseline scope of work is necessary to ensure that critical deliverables are completed within the available funds. The project manager has developed a list of potential options. The Committee is encouraged by these efforts to identify and evaluate such options. This process must continue with the participation by project staff and CERN.

In the past several months, the U.S. LHC Accelerator Project Manager has devoted special effort to identifying and controlling cost growth for the BNL work. The Committee finds that this effort has been effective. Continued vigilance is needed.

Recommendations

1. Establish project contingency at 20 percent of the cost to complete.
2. Examine whether additional staff is needed in the Project Office to monitor sub-project costs and schedule.
3. Provide, by the next quarterly status meeting, a complete technical, cost and schedule plan for participation in the first octant test at LHC in 2004.
4. The U.S. LHC Accelerator Project Manager should exercise caution in the review and approval of additional baseline change requests.
5. Conduct a project-wide cost and risk analysis with the goal of mitigating cost overruns beyond the available contingency.

ACTION ITEMS

1. Conduct a DOE/NSF Project Manager's Quarterly Status Meeting in September 2001.
2. Conduct a DOE Review in November 2001.